U.S. ATLAS M&O Estimate
WBS Dictionary

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WBS Number	Description
3.3	**Liquid Argon M&O Estimate** The M&O estimate for the Liquid Argon Calorimeter includes costs for Pre operations, Operations, Maintenance, CERN common costs, and CERN living expense supplements.

WBS Number	Description

3.3.1 **Pre operations**

Comments: Pre operations shall include:
1. Updating the documentation in CDD format to include all the changes to the hardware from the pre operations stage of the experiment. The documentation to be updated includes drawings, procedures and software as a minimum.
2. Acceptance test procedure, and data recording.
3. Integration tooling and fixtures
4. Cryostat operations on the surface (common cost item)
5. Facilities setup that include as a minimum, equipment, and a safety program
6. Electronics support that includes supervision of staff and planning and control.
7. Preoperations of hardware.

3.3.1.1 **Electronics pre operations**

During the pre operations stage of the experiment, the documentation in CDD format will be updated to reflect the changes made to the hardware during commissioning . An integration acceptance test procedure will be generated and data recorded. In addition, integration tooling and fixtures will be developed for integrating level 3 subsystems. One facility will be set up to house the pre operations, and maintenance functions of the electronics for the Liquid Argon Calorimeter. The System Crate, Optical links receiver, Level 1 trigger system, and ROD System will require costs for pre-operations. These costs were not included in the construction project. An overall burn-in of the integrated system crate will be performed to flush out infant mortality components before the commencement of operations. This cost also was not included in the construction project.

3.3.1.1.1 **Documentation Update**

During the pre operations stage of the experiment, the documentation in CDD format will be updated to reflect the changes made to the hardware during commissioning and acceptance testing for all level 3 subsystems. The documentation to be updated includes drawings, procedures, and software.

3.3.1.1.2 **Integration**

Sub system Integration Integration testing, tooling, & documentation

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Comments: The test procedure and data recorded will require ¼ FTE of an electrical engineer and ¼ of a technician in FY04. The tooling and fixtures for integration testing will require 1/10 of an electrical engineer to design and ¼ FTE of a technician to manufacture and debug in FY04. Travel - 2 trips to CERN at $2500/trip or $5,000.

Base & infrastructure
Labor costs assumes ¼ experienced Physicist in FY04 for technical guidance and decision making during integration. Travel –1 trip at $2500 /trip will be required

3.3.1.1.3 **Facilities**

Facilities, for housing the pre operations and maintenance functions

Comments: Labor costs assume ¼ mechanical designer needed to provide layout of facility to support pre operations and maintenance. 1 FTE technician is needed to follow up procurements and set up equipment in the facility. All are required in FY04. Office equipment, phones faxes and supplies will be part of the CERN common costs. Travel – 3 trips at $2500/trip or $7500 will be required.

3.3.1.1.4 **Pre-operations**

Commissioning costs not covered in the construction project

3.3.1.2 **Mechanics pre operations**

During the pre operations stage of the experiment, the documentation will be updated in CDD format to reflect the changes made to the hardware during commissioning . One facility will be set up to house the pre operations, and maintenance functions of the mechanics for the Liquid Argon Calorimeter. In addition, a special calorimeter module for the FCAL will be required to measure the tails of the hadronic showers in the EME/HEC/FCAL beam test.

3.3.1.2.1 **Documentation Update**

During the pre operations stage of the experiment, the documentation will be updated in CDD format to reflect the changes made to the hardware during commissioning for all level 3 subsystems. The documentation to be updated includes drawings, procedures, and software.

3.3.1.2.2 **Facilities**

Facilities to support pre operations and maintenance

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Comments: Labor costs assume ¼ mechanical designer needed to provide layout of facility to support pre operations and maintenance. 1/2 FTE technician is needed to follow up procurements and set up equipment in the facility. All are required in FY03. Office equipment, phones faxes and supplies will be part of the CERN common costs. Travel – 2 trips at $2500/trip or $5000 will be required

Base & infrastructure
Labor costs assume 1/10 Physicist in FY03 for support in facility layout and insuring that equipment functions properly. Office equipment, phones faxes and supplies will be part of the CERN common costs. Travel - 1 trip or $2,500 will be required

3.3.1.2.3 **Fcal Hadronic Tail Measurement**

During comprehensive reviews, the LHCC referees stated that the tails of hadronic showers be measured to provide the system response calibration. In order to measure the hadronic shower tails at the pre operations level, a special calorimeter module located downstream of the module 0 calorimeter has to be built. Arizona has been assigned the leadership role in the test and will take on additional responsibilities. The test beam is available at CERN during FY03 and FY04 only.

Comments: The costs for the Liquid Argon tail catcher module are:

Design and Engineering	1/10 FTE ME in FY03
Materials	$12,000 in FY03
Construction	1/3 FTE MT In FY04
Shipping & installation	1/10 FTE ME in FY04
Commissioning and Test beam setup	1/3 FTE MT in FY04
Mount	1/20 FTE ME in FY04
Cabling and Connections	1/4 FTE ME in FY03
Software	1/6 FTE SW Prof. In
FY04	1/6 FTE SW Prof. In FY04

Travel 3 trips/year in FY03 and FY04 at $2,500/trip or $15,000

Base & infrastructure
Labor costs assumes 1 FTE faculty and 1/2 FTE post doc per year in FY03 and FY04 to supervise and provide technical support.

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3.3.2 **Operations**

Operations shall include:
Calibration and monitoring of the equipment during experiment run time
Maintaining databases
ATLAS data taking
Maintenance for accessible parts
Electronics support that includes supervision of staff, planning and control

3.3.2.1 **Electronics Operations**

Calibration and monitoring of the equipment will be performed during the experiment run time that is expected to start in FY07. ATLAS data taking, database maintenance, and electronics support will be provided. Routine checking and maintenance will be carried out for accessible parts of the subsystem. For those parts of the system that are inaccessible, failures will be logged and whatever recovery procedures are necessary will be executed. Electrical, software, and physicist technical support and management will be required.

3.3.2.1.1 **Operations hardware support readout electronics**

Operations hardware support readout electronics

Comments: 7/4 FTE ET per year starting in FY07 and FY08 and 1 FTE ET in FY09 to FY012 will be required to support electronics boards, and take ATLAS data during FY07 and FY08. Travel 4 trips per year at $2500 per trip or $50,000

Base & infrastructure
1/4 FTE experienced physicist, 1 FTE faculty, 2 FTE postdocs, and 2 grad students will be required to support hardware and provide technical expertise in FY07 and FY08 and 0.2 FTE faculty, 1 FTE post, and 1 grad student during FY09 to FY012. Doc during the operations phase of the experiment. Travel 4trip/year at $2,500 per trip or $60,000.

3.3.2.1.2 **Operations Software Support**

Provide software support for monitoring and software upgrades during operations. Some of the areas that require software support are power supplies – monitoring delivered voltages, effects of radiation; crate controls – status of the cooling system, crate voltages and temperatures; operations of FEBs and other boards inside the crates; optical links; ROD CPU operations and ROD processing units operations and calibration system. In addition, the slow controls software will have to be maintained due to the ever changing computing environment.

WBS Number	Description
3.3.2.1.3	**Operations Physicist support and management**
	Provide supervision and technical support to the operations phase
3.3.2.1.4	**Operations Physicist Support and Management**
	Operations Physicist support and management for Pittsburgh equipment and or software
	Comments: Labor cost assumes 1/2 FTE faculty, 1/2 FTE postdoc, 1 FTE grad student FY05 to FY08 and 2/10 faculty, 1/5 FTE grad student in FY09 to FY12dedicated for problems that will occur in operations of the level 1 trigger.
3.3.2.2	**Mechanical operations**
	During the operations phase, personnel will be required to provide hardware support, software support and supervise the operations of the cryostat, the Liquid nitrogen refrigeration system, the quality meter monitors, HV Feedthroughs and the FCAL
3.3.2.2.1	**Mechanical operations cryostat**
	Provide hardware and software support to the cryostat during the operations phase
	Comments: The hardware and software support consists of monitoring the cryostat controls for temperature, pressure, and liquid levels. Labor costs assume 1/8 FTE ME for hardware support, and 1/8 FTE SW Prof for software support starting in FY06 to FY12. Travel – 1 trip/year at $2500/ trip or $17,500
3.3.2.2.2	**Mechanical operations Quality Meter**
	The Quality Meter consists of the mechanical system and electronic cards that provide capacitance to current conversion. Costs are based on providing mechanical, electrical hardware and software support to the quality meter during the operations phase.
	Comments: The software support consists of monitoring the quality meter controls for temperature, pressure, and liquid levels. Labor costs assume 1/8 FTE ME, and 1/8 FTE EE for hardware support, and 1/8 FTE SW Prof for software support starting in FY06 to FY12. Travel 2 trips/year at $2500/ trip or $35,000
3.3.2.2.3	**Mechanical operations Cryogenics**
	Provide hardware and software support to the cryogenics during the operations phase.

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Comments: The software and hardware support consists of monitoring the cryogenics controls for temperature, pressure, and liquid levels and provides upgrades to the BNL generated code. Labor costs assume 1/4 FTE ME in FY06 to FY12 for hardware support, and 1/4 FTE SW Prof for software support starting in FY06 to FY12. Supervision of cryogenic personnel requires 1/4FTE ME in FY06 to FY12. Travel – 2 trips/year at $2500/ trip or $35,000

3.3.2.2.4 **Mechanical operations HV Feedthroughs**

Provide hardware support to the High Voltage Feethroughs during the operations phase.
Monitoring and control of the HV feedthrough temperature and nitrogen gas flow will be required.

Comments: Labor costs assume 1/10FTE ME starting in FY07 to FY12, monitoring equipment cost of $5000 consisting of CANBUS I/O and a PC in FY06 is required. Travel 1 trip/year at $2500/trip or $15000.

3.3.2.2.5 **Mechanical operations FCAL**

Provide hardware and software support to the FCAL during the operations phase. The software support consists of monitoring the FCAL controls for temperature, pressure, and liquid levels and provides changes to the software.

WBS Number | **Description**

Comments: Labor costs assume ¼ FTE ME starting in FY06 to FY08 and ¼ FTE SWP of software starting in FY06 to FY08 and 1/10 FTE ME and 1/10 FTE Software professional in FY09 to FY12. Travel 2 trips/year at $2500/trip or $35,000

Base and Infrastructure
Hardware support for this effort will require:
FY06 to FY08
- 1 FTE faculty
- 0.5 FTE Post doc
- 1 FTE grad student

FY 09 to FY12
- 2/10 FTE faculty
- 1/4 FTE post doc
- 1/4 FTE grad student

Base & infrastructure
Effort required for the software controls consists of:
FY06 to FY08
- 1/2 FTE faculty
- 1/3 FTE software professional
- 1/2 FTE grad student

FY 09 to FY12
- 1/4 FTE faculty
- 2/10 FTE software professional
- 1/2 FTE grad student

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3.3.3	**Maintenance**

Maintenance shall include:
Spare part kit to repair at the CERN and institution sites. The spare parts shall account for part wear out rate, and part obsolescence.

Scheduled maintenance that includes equipment removal and reinstallation, calibration and alignment, test equipment at the CERN and institution sites, on site repair, and off site repair.

Project Management to supervise the staff and perform project maintenance planning and control

3.3.3.1 **Maintenance of electronic equipment**

Maintenance of the Liquid Argon Calorimeter electronics can be split into seven categories:
Front End Electronics
Level 1 trigger interface
ROD system electronics
Power Supplies
Detector Control and cooling systems
Cables, crates, and connectors
Optical Links
During access, failed units will be repaired or replaced with spares. Repair of these failed modules will be performed at CERN by the maintenance staff or at the US ATLAS manufacturing site during the following running period.
The maintenance staff at the CERN site for the (LAr) electronics will consist of one manager, and five technicians; one who have special expertise in one or more of the above areas. If the repair decision is to be off site, due to technical complexity and/or cost, at least one technician experienced in each of the above areas shall be maintained at the manufacturing institution. Each of the level 3 systems will require equipment for the testing of system components. Some of this will be specialized test equipment (such as an operating front end crate, spectrum analyzer, TDR etc.) and some will be normal electronic tools (oscilloscopes, meters etc.) that will be expensed under CERN common costs. The specialized test equipment, which will be quite heavily used, must be kept operational and up to date. For the purpose of estimating the maintenance cost for such equipment, it was assumed that it would be replaced every three years.The estimate is based on working 200days/year and that 50 days/year will be used for access, leaving 150days (a total of 900 MD per year) for on site repair and maintenance.

3.3.3.1.1 **Maintenance of electronic front end readout**

WBS Number	Description

The number of front end boards installed in the system is:

Type	Number Installed
Front End Board	1524
Calibration Board	122
Calibration Shaper (FCAL)	2
Tower Builder Board	120
Tower Driver Board	20
Controller	114
Monitoring Board	146
LV Boards (HEC)	24
Total	2072

The probability of failure: 5%/year

Fraction of failures that are not repairable: 20%

Comments: Repair of the front end boards will consist of replacing the board with a spare during access, then diagnosing the problem during the following running period. Two assumptions are based , 1% of the modules will be replaced each year and that 4% will be repaired. The estimated construction cost of the entire system, in round numbers, is about $ 20M, of which 2/3 are in the readout electronics modules. Thus the cost of replacing modules is estimated to be 0.01 X $13.3M = $133K/year. Assuming that the mean time to repair each module is one day, and one day is used for calibration, the required manpower for repair is 0.04 X 2072 X 2 = 164 Man Days.The cost of parts, as mentioned above, will be dominated by the package costs of custom ICs. Assuming these will be about $6.6 K/year for about 10 ICs, the total parts cost will be $66.6K/year. These items will be purchased in FY05 with a $150k costs and FY06 with a $156k costs The test station for the front end electronics will be needed to include a front end crate, equipped with a calibration board and a controller module. A ROD crate with at least one ROD module and a readout computer also will be required. Test instruments will include an oscilloscope, a pattern generator and a logic analyzer. The cost of maintaining this setup is estimated to be about 20$K/year. The technical staff off site at the responsible institutions are needed to provide technical expertise is 1 FTE EE/year.

Summarizing the costs:

Labor EET 164MD/year or ¾ FTE +EE 1FTE starting in FY07 to FY08 and 1/2 FTE EE and 1/2 FTE ET for FY09 to FY12.

Spares $150k in FY05, 156k in FY06 to pay back CERN loan, $0 in FY07 and FY08, $93k in FY 09 $133k/year in FY 10 to FY12

Spare parts $150k in FY05 and $156k in FY06

Equipment $ 20K/year in FY07 to FY12

Travel 3 trips at $2500 per trip or $45,000

Base & infrastructure

Labor assumes ½ FTE/year in FY07 to FY08 and 1/4 FTE/teatr in FY 09 to Fy12 of an experienced physicist to provide technical support to the maintenance task off and on-site. Travel 1 trip /year at $2,500 per trip or $15,000/year

3.3.3.1.2 **Maintenance of electronic Level 1 trigger**

The receiver/monitor system, located in the USA015 cavern, will consist of 6 9-U VME crates filled with 16 modules each, each of which contains 64 analog channels.

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Comments: Assuming a failure rate of 5%/year for these modules, there will be 5 failures/year, one of which is not repairable, and will need to be replaced. The cost of an individual module is approximately $6.6K. It was assumed 1 man day to repair and 1 man day to calibrate these modules, so the total repair time for this system is 8MD/year. The test setup will include an oscilloscope, a pulse generator, and a receiver crate, which can be maintained for $6.6K/year. The technical staff off site at the responsible institution is needed to provide technical expertise at ¼ FTE EE/year.

Summarizing the costs:

Labor	EET 8MD/year or 1/10 FTE +EE ¼ FTE starting in FY07 to FY12
Replacement	$6.6K/year in FY07 to FY12
Equipment	$6.6k/year in FY07 to FY12
Travel	2 trips/year at $2500 per trip or $30,000

Base & infrastructure

Labor assumes ¼ FTE/year starting in FY07 to FY08 and 1/10 FTE in FY09 to FY12 of an experienced physicist to provide technical support to the maintenance task off and on-site. Travel 2 trip /year at $2,500 per trip or $30,000.

3.3.3.1.3 **Maintenance of the ROD**

The modules in the ROD system (not including TTC hardware) are listed as:

Type	Number installed
Rod Modules	820
TBM Modules	54
SPAC Modules	54
Total	928

The location of this system is not yet established, but it will be accessible. Assuming a failure rate of 5%/year, 20% of which are not repairable, 9 modules/year will have to be replaced.

Comments: The cost of these modules is not yet known, but for these purposes it was assumed that they are similar to VME processors, which are about $6.6K each. The replacement costs are therefore, estimated to be $60K/year. Assuming construction and testing of a new module will require 4 MD. So the manpower to produce 9 new modules per year will be 4 X 9 = 36 MD/year. Assuming that the repair time for a module is 2 MD, the manpower required to repair modules in the ROD system is estimated to be 4 X 38 = 76 MD/year. The components for repair are estimated to be 5% of the cost of the completed board, or $333.3/board. Thus the average cost of components to repair the boards is $333.3 X 38 = $12.6K/year, and the manpower needs for the ROD system is 112 MD/year.

The crate controllers will be under a maintenance contract, for which we expect to pay 10% of the cost of the module per year, which yields 54 X 0.1 X $6.66 = $36K/year.

For the workstations, it is estimated that these will be PCs, and will need to be upgraded once every 3 years at a cost of $2.6K. The upgrade costs will be 10 X $2.6/(3 years) = $8.6/year. It is assumed that maintenance for these machines, as well as any software maintenance, upgrades, licensing costs for these machines or the crate controllers will be borne by the trigger/DAQ group. The maintenance/upgrade costs for the ROD computing systems are:

Type	Number installed	Maintenance Costs	Replacement costs
Crate Controllers	54	$36K/year	$72K/year
Work stations	10	--------	$ 1K/year
Total		$36K/year	$73K/year

The setup required to maintain the RODs will include a ROD crate and processor, a test pattern generator, a VME timing analyzer, a logic analyzer, and one or more oscilloscopes. It is estimated that the cost to maintain this setup will be $20k/year. The technical staff off site at the responsible institution needed to provide technical expertise is ½ FTE EE/year.

Summarizing the costs:

Labor	EET 112MD/year or ½ FTE +EE ½ FTE starting in FY07 to FY12
Replacement	$140K/year in FY07 to FY12
Spare parts	$12.6K/year in FY07 to FY12
Maintenance Contracts	$ 36K/year starting in FY07 to FY12
Equipment	$ 20k/year in FY07 to FY12
Travel -	2 trips/year at $2500 per trip or $30,000

3.3.3.1.4 **Maintenance of the Power Supplies**

WBS Number | **Description**

There are 4 main types of power supplies. They are:

Type	Number installed	Number of units/supply
Front End Crate Supplies	63	18
ROD VME crate Supplies	54	4
Level 1 Interface Crate Supplies	6	4
HEC LV Supplies	8	12

Supplies located in high radiation areas will have a high probability of failure (10%/year)

Comments: Repair of switching supplies will consist of replacing the supply with a spare during access, then replacing the bricks, which have failed during the following running period.
For the front end electronics, the number of such failures is estimated to be 0.1 X 63 X 18 = 113 bricks/year. For the LV supplies for the HEC, the corresponding number is 0.1 X 8 X 12 = 10 bricks/year, bringing the total to 123 bricks/year. If the cost of each brick is
$133.3, this will contribute about $16.6K/year to the maintenance cost. Assuming that each replacement job requires ½ day, the manpower required to service the front end electronics is estimated to be 40 MD/year. It is assumed that these two systems comprise the largest part of the supply maintenance problem, but probably not more than half of it. To obtain an estimate for all of the power supply maintenance, the assumption is to double these figures. It is envisioned a test station that will include an oscilloscope and a spectrum analyzer. The cost to maintain such a system is about $20K. The technical staff off site at the responsible institution needed to provide technical expertise is 1 FTE EE/year
Summarizing the costs:

Labor	EET 120MD/year or ½ FTE +EE 1 FTE starting in FY07 to FY12
Spare parts	$33.3K/year in FY07 to FY12
Equipment	$ 40k/year in FY07 to FY12
Travel	2 Trips/year at $2500 per trip or $30,000

Base & infrastructure
Labor assumes 1 FTE/year in FY07 of an experienced physicist to provide technical support to the maintenance task off and on-site. Travel 2 trips /year at $2,500 per trip or $30000.

3.3.3.1.5 **Maintenance of the Optical Links and System Cables**

WBS Number	Description

The Optical Link components are:

Connection	Type	Number Installed
FEB-ROD	optical	1524
ROD-FEB	optical/Cu	762
System FEB crate	optical	114
FT-Baseplane	Cu (flex)	3048
TBB – Receiver	Cu (shielded TP)	240
TDB – Receiver	Cu (shielded TP)	120

The optical links are active devices and are therefore subject to component failure.

Comments: Assuming that the transmitters will fail at a rate of 5% per year, and the repair is to replace the part, the cost for this task is $53.3K, and is based on a transmitter cost $266.6/transmitter. The associated labor, assuming ½ MD per replacement is 38MD.

Copper cables are passive, so component failure is not a problem. Oxidation does occur, and at the same rate, the flex cables will need to be replaced and the connectors on the trigger cables will also have to be replaced. The cost associated with this maintenance is only manpower. It is assumed that the time to replace either is ½ MD and that the probability of failure is 1%/year. This leads to a manpower cost of) 0.01 X (3048+240+120) X 0.5 = 17 MD/year. The cost for each flex cable is about $333.3, leading to a replacement cost of $10K/year. The test equipment required will include optical link and cable testing equipment. The maintenance budget for this item is estimated at $15K/year The technical staff off site at the responsible institution needed to provide technical expertise is ½ FTE EE/year

Summarizing the costs:

Labor EET 55MD/year or ¼ FTE +EE ½ FTE starting in FY07 to FY08 and 1/10 FTE EET and 1/4 FTE EE for FY09 to Fy12

Failure replacement needs are assumed to decrease by 50% for FY09 to FY12

Spare parts	$53.3K/year in FY07 to FY12
Replacement	$ 10K/year in FY07 to FY12
Test set maintenance	$ 15K/year in FY07 to FY12
Travel -	2 trips/year at $2500 per trip or $30,000

Base & infrastructure

Labor assumes ½ FTE/year in FY07 to FY08 of an experienced physicist to provide technical support to the maintenance task off and on-site, and 1/2 FTE faculty, 1/2 postdoc, and 1 FTE grad student. All support is reduced by 50% for FY09 to FY12.Travel 2 trips /year at $2,500 per trip or $30,000

3.3.3.1.6 **Maintenance of the Crates**

WBS Number	Description
	The Front End Crates should require little maintenance, except for the case when a baseplane needs to be replaced due to a bad connector. This is a major repair job that must be done during the access period.
	Comments: Manpower during an access is not counted in this estimate, as all available personnel will probably be used for the time available. However, the baseplane replacement cost is included. Assuming a failure rate of 1% (1 baseplane per year) the replacement cost will be $3.33K/year. The technical staff off site at the responsible institution needed to provide technical expertise is 1/10 FTE EE/year Summarizing the costs: Labor EET 0.1FTE/year starting in FY07 to FY12 Replacement $3.33K/year starting in FY07 to FY12
3.3.3.1.7	**Maintenance of the DCS and Cooling Systems**
	The Detector Control System(DCS) system is clearly a critical area for maintenance, as it is heavily relied on for the maintenance of other operations. The equipment used in this system is particularly robust, so one might expect the replacement and spare parts to be low, compared to other systems.

Comments: A rough estimate is 1% of the cost of the installed electronics per year would be needed for replacement. The total cost of the DCS electronics is estimated at $100K, so it estimated that about $2K/year for replacement costs for this system.

Maintenance costs for the cooling system are also difficult to estimate, due to a lack of experience with this type of equipment. Monitoring of the system will be especially important, since a cooling failure can have disastrous consequences for the electronics. It is assumed that cooling plates (of which there are 3048 in the experiment) will need to be replaced at some rate, approximately 40 per year, at a cost of $66.6 each. The job of removing and reattaching a cooling plate is long, due to the large number of screws and the care required when handling a front end board. It is estimated that there will be a need for ½ MD per plate for replacement. The setup needed to test both the DCS and the components of the cooling system will be one DSC station to test and service all monitoring equipment, and a spare cooling circulation system. It is estimated the cost to maintain this system will be $6.6K. There is a cooling system for the power supplies, but the cooling plates used in that system are more robust, and will probably have a much smaller maintenance problem. The technical staff off site at the responsible institution needed to provide technical expertise is 1.25 FTE EE/year.

Summarizing the costs:

Labor	ET 25MD/year or 1/10 FTE +EE .25 FTE starting in FY07 to FY12
Spare parts	$6.6K/year in FY07 to FY12
Replacement	$ 4K/year in FY07 to FY12
Equipment	10K/year in FY07 to FY12
Travel -	2 trips/year at $2500 per trip or $30,000

Base & infrastructure

Labor assumes ½ FTE/year in FY07 and FY08, and 1/4 FTE/year in FY09 to FY12 of an experienced physicist to provide technical support to the maintenance task off and on-site. Travel 2 trips /year at $2,500 or $30,000.

3.3.3.1.8 **Maintenance of the Electronics facility**

Facility maintenance including replacement of broken equipment

Comments: Facility maintenance including replacement of broken equipment. $25k/year from FY 04 to FY12

3.3.3.2 **Maintenance of mechanical equipmnt**

WBS Number	Description

US ATLAS maintenance tasks will be required on the following level 3 subsystems A. Cryogenics, B. Quality meter, C. HV Feedthroughs
The cryostat and FCAL will be accessed for maintenance approximately every ten years and therefore no cost for maintenance will be estimated. The, Cryogenics, Quality Meter and HV Feedthroughs, will require US ATLAS manpower to support maintenance functions at CERN. The HV Feedthroughs and Quality Meter, will also require spare parts on hand at CERN to support the maintenance task. During access, failed units will be repaired or replaced with spares. Repair of these failed modules will be performed at CERN by the maintenance staff. The estimate is based on working 200days/year and that 50days/year will be used for access, leaving 150 days (a total of 900 man days per year) for on site repair and maintenance.

3.3.3.2.1 Maintenance of the Cryogenics system

Maintenance of the Cryogenics system

Comments: Labor costs assume 0.2 ME in FY07 and FY08, and 0.12 FTE ME in FY09 to FY12. Cost for spare parts is based on 15% of construction manufacturing cost or $30K/year in FY05 to FY12. Travel 1 trip/year at $2500 per trip or $15,000

3.3.3.2.2 Maintenance of the Quality Meter

Maintenance of the Quality Meter

Comments: Labor assumes ME 1/12 FTE if FY07 1/4 FTE in FY08 to FY12 for maintenance and recalibration costs. Spare parts cost for the quality meter mechanical parts and for the electronic boards is $50K/year starting in FY05 to FY12 .Travel 1 trip/year at $2500 per trip or $17,500

3.3.3.2.3 Maintenance of the HV feedthrough

Maintenance of the HV feedthrough

Comments: Labor assumes 1/12 FTE ME in FY07, and FY08 and 1/10 FTE ME in FY09 to FY 12 for maintenance at the CERN site.
Cost for spare parts is $10K starting in FY05 to FY12. Travel – 1 trip/year at $2500/trip or $17,500.

Base and infrastructure support for the HV feedthroughs:
1/2 FTE faculty in FY07 and FY08 and 1/10 faculty in FY09 to FY12.
1/2 grad student in FY07 and FY08 and 1/4 grad student in FY09 to FY12.

3.3.3.2.4 Maintenance of the mechanical facility

WBS Number	Description	3.3.3

Maintenance of the mechanical facility including replacement of broken equipment

Comments: Maintenance of the mechanical facility including replacement of broken equipment $5k/year from FY03 to FY012.

WBS Number	Description
3.3.4	**CERN living expenses**
	3.3.4 CERN living expenses supplements for electronics and mechanics support,
	Comments: CERN living expenses supplements for electronics and mechanics support, is estimated at $30K/FTE. 4FTEs in FY05, FY06 and FY0& 6FTEs in FY08 to FY12. This includes higher cost of living, additional cost of CERN based health insurance, and overhead.

WBS Number	Description
3.3.5	**CERN common costs**
	CERN common costs include US ATLAS share of costs levied by CERN, and costs associated with CERN facilities usage, equipment, and services
3.3.5.1	**CERN common costs**
	The CERN common costs includes the costs for pre operations, operations, and maintenance. The US ATLAS share is 22% of the total CERN common costs for the experiment.

WBS Number **Description** **3.3.5**

Comments: LAr ATLAS M&O Common Costs kCHF

Description	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Totals
Mechanics	0				0	0	0			0	0
Gas-System	0	0	0	0	0	0	0	0	0	0	
Cryo-System	10	10	5	5	30	30	30	30	30	30	
Cooling System					50	100	100	100	100	100	5
FE Electronic (spares)						350	350	350	350	350	17
Standard electronics, PS (LV,HV)					20	20	20	20	20	20	1
Standard electronics, Crates	85	40	20	115	80	130	130	130	130	130	99
Standard electronics, RO Modules				30	50	200	200	200	200	200	10
Controls, (DCS, DSS)				10	30	30	30	30	30	30	
Sub-Detector Spares											
Areas	30	15	15	10							
Communications					10	10	10	10	10	10	
Store Items				120	110	160	160	160	160	160	1(
Hired manpower @CERN (6)	15	5	5	305	780	880	880	880	880	880	55
TOTALS	140	70	45	595	1160	1910	1910	1910	1910	1910	1156

Cryo-System	LAr 1.2 CHF, also FEC cooling gases
Cooling System	Cooling for FEC systems and power supplies
FE Electronic (spares)	FEB spares arranged as payment advancement
Standard electronics, PS (LV,HV)	Replacement of 1 PS per year
Standard electronics, Crates	Electronic pool rentals, test beam electronics (VMEs); DVMs, TDRs, oscilloscopes
Standard electronics, RO Modules	On-line computing (PCs, RODs, links,software licences)
Controls, (DCS, DSS)	Replacement of local DCS/ELMBs; safety equipment
Areas	Test beam operations, consumables
Communications	GSM phones, call-back
Store Items	Sheet metal for repairs
Hired manpower @CERN (6)	Systems managers, technicians, welders, cleaners

LAr USATLAS M&O Common Costs k$ (USATLAS/ATLAS = 22%)

WBS Number	Description	
		3.3.5

Description	2003	2004	2 005	2006	2007	2008	2009	2010	2011	2012	Totals
Mechanics	0	0	0	0	0	0	0	0	0	0	0
Gas-System	0	0	0	0	0	0	0	0	0	0	0
Cryo-System	1.47	1.47	.07	.07	4.4	4.4	4.4	4.4	4.4	4.4	29.48
Cooling System					7.33	14.66	14.66	14.66	14.66	14.66	80.63
FE Electronic (spares)						51.31	51.31	51.31	51.31	51.31	256.55
Standard electronics, PS (LV, HV)				2.95	2.95	2.95	2.95	2.95	2.95	2.95	20.65
Standard electronics, Crates	12.24	5.86	2.93	16.86	11.73	19.06	19.06	19.06	19.06	19.06	144.92
Standard electronics, RO Modules				4.40	29.32	29.32	29.32	29.32	29.32	29.32	180.32
Controls, (DCS, DSS)				1.47	4.41	4.41	4.41	4.41	4.41	4.41	27.93
Sub-Detector Spares										0	
Areas	4.4	2.2	2.2	1.47							10.27
Communications					1.47	1.47	1.47	1.47	1.47	1.47	10.29
Store Items				17.61	16.13	23.45	23.45	23.45	23.4 5	23.45	151
Hired manpower @ CERN (6)	2.2	0.73	0.73	44.7	114.34	129	129	129	129	129	807.71
TOTALS	20.3	10.3	5.93	89,53	192.08	280	280	280	280	280	

WBS Number	Description	
	1718	
	The above estimates are based on 1.5kchf=$1k.	The estimate in Access is based on 1.4kCHF=$1k